THE INL SEISMIC RISK ASSESSMENT PROJECT: REQUIREMENTS FOR ADDRESSING DOE ORDER 420.1C & A PROPOSED GENERIC METHODOLOGY

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INL Seismic Risk-Informed Methodology Independent Review Panel

Eighth Meeting of CNS Seismic Lessons Learned Panel
Idaho National Laboratory, Idaho Falls, ID
May 27, 2015

Outline of Talk

- Motivation for risk-informed methodology
- DOE Order 420.1C and guidance regarding the need for updating existing NPH-Seismic assessments
- Proposed *preliminary* generic risk-informed approach to address Order and other updating requirements
- Suzette Payne will follow with discussion of SL1 PSHA for INL
- Justin Coleman will follow with the risk-informed approach being implemented for INL

Motivation for INL Seismic Risk-Informed Methodology

- DOE nuclear facilities must comply with DOE Order 420.1C *Facility Safety*
- Requires a review their natural phenomena hazards (NPH) assessments no less than every ten years to evaluate the need for an update based on current knowledge
- Order points to DOE-STD-1020-2012 for criteria to be considered in the 10-year evaluation, also ANSI/ANS-2.29-2008 and NUREG-2117.
- DOE Order aimed at assuring the *safety of nuclear facilities*—function of both seismic hazard as well as the facility capacity—the inclusion of risk information appears to be in line with the spirit and objectives of the Order
- Purpose of this risk-informed methodology is to provide a systematic approach for evaluating the need for an update of an existing PSHA that will meet the Order and provide a documented basis for the decision.
- Focus on INL facilities, but may be applicable to other facilities and sites.
- Comments are welcome on this preliminary methodology

d. Review and Upgrade Requirements for Existing DOE Facilities.

(1) Existing facility or site NPH assessments must be reviewed at least every 10 years for any significant changes in data, criteria, and assessment methods that would warrant updating the assessments. Section 9.2 of DOE-STD-1020-2012 contains criteria and guidance for performing these reviews. The review results, along with any recommended update actions, must be submitted to the head of the field element. If no update is necessary, this result must be documented following the review.

(2) If a new assessment of NPH demands indicates deficiencies in existing SSC design, a plan for upgrades must be developed and implemented on a prioritized schedule, based on the safety significance of the upgrades, time or funding constraints, and mission requirements. Section 9.3 of DOE-STD-1020-2012 contains guidance on performing upgrade evaluations.

DOE-STD-1020-2012 *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*

- **9.2. Periodic Review and Update of NPH Assessments**
- 9.2.1 At a frequency not to exceed ten years, the following aspects of NPH assessments shall be reviewed for changes that would warrant updating the assessments:
  - NPH data and data collection methods;
  - NPH modeling techniques, either generic or specific to the region of interest; and
  - NPH assessment methods.
- 9.2.2 Consistent with DOE 420.1C, a preliminary estimate of whether changes to data, models, or methods are "significant" and warrant updating the assessments should be performed and consider the following criteria:
  - Are the changes to data, models, or methods likely to cause a change in the estimates of the major inputs to hazard calculations?
  - Given potential changes to the hazard inputs, by what magnitude might the calculated hazard results change, and how might the results impact current site design standards?
- 9.2.3 The preliminary estimate of how hazard results might change from new inputs will likely be imprecise. An expected significant increase in the hazard results would clearly favor completion of a new assessment. However, even if hazard results are not expected to change significantly, large changes to the input parameters may warrant a new assessment to ensure the NPH assessment continues to have a viable technical basis.
- 9.2.4 In the case of seismic hazard assessments, a determination of whether an existing assessment remains adequate for future use should consider the criteria in Section 4.1 of ANSI/ANS-2.29-2008 for the suitability of existing studies. Additional guidance on the bases for updating existing seismic assessments can be obtained from NUREG-2117, *Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies*.
- 9.2.5 A decision on updating an NPH assessment should consider the intended application of the assessment results.

ANSI/ANS- 2.29-2008 on Updating Existing PSHA

- 4.1 High Level Requirements
- "…the PSHA analyst may have the option to use an existing seismic study as a starting point for a site-specific assessment."
- HLR-A: Scope
  - "The assessment of the frequency of earthquake ground motions at a site shall be based on a PSHA that considers the epistemic uncertainty in the analysis inputs and that reflects the composite distribution of the informed technical community. The level of the analysis shall be determined based on the intended application of the PSHA results and on site-specific complexity (see Sec. 4.3). For PSHA levels 3 and 4, the analysis shall include a site-specific detailed analysis."
- HLR-B: Data collection
  - [develop a comprehensive up-to-date database per ANSI/ANS-2.27-2008]

ANSI/ANS- 2.29-2008 on Updating Existing study (cont'd.)

- HLR-C: Seismic source characterization
- HLR-D: Ground motion characterization
- HLR-E: Local site effects
- HLR-F: Quantification
  - [Epistemic and aleatory uncertainties included in each element of PSHA]
- HLR-G: Use of existing studies
  - "When use is made of an existing study for PSHA purposes, it shall be confirmed that the basic data and scientific interpretations in the original analysis are still valid in light of current information, the study meets the requirements outlined in HLR-A through HLR-F above, and the study is suitable for the intended application."

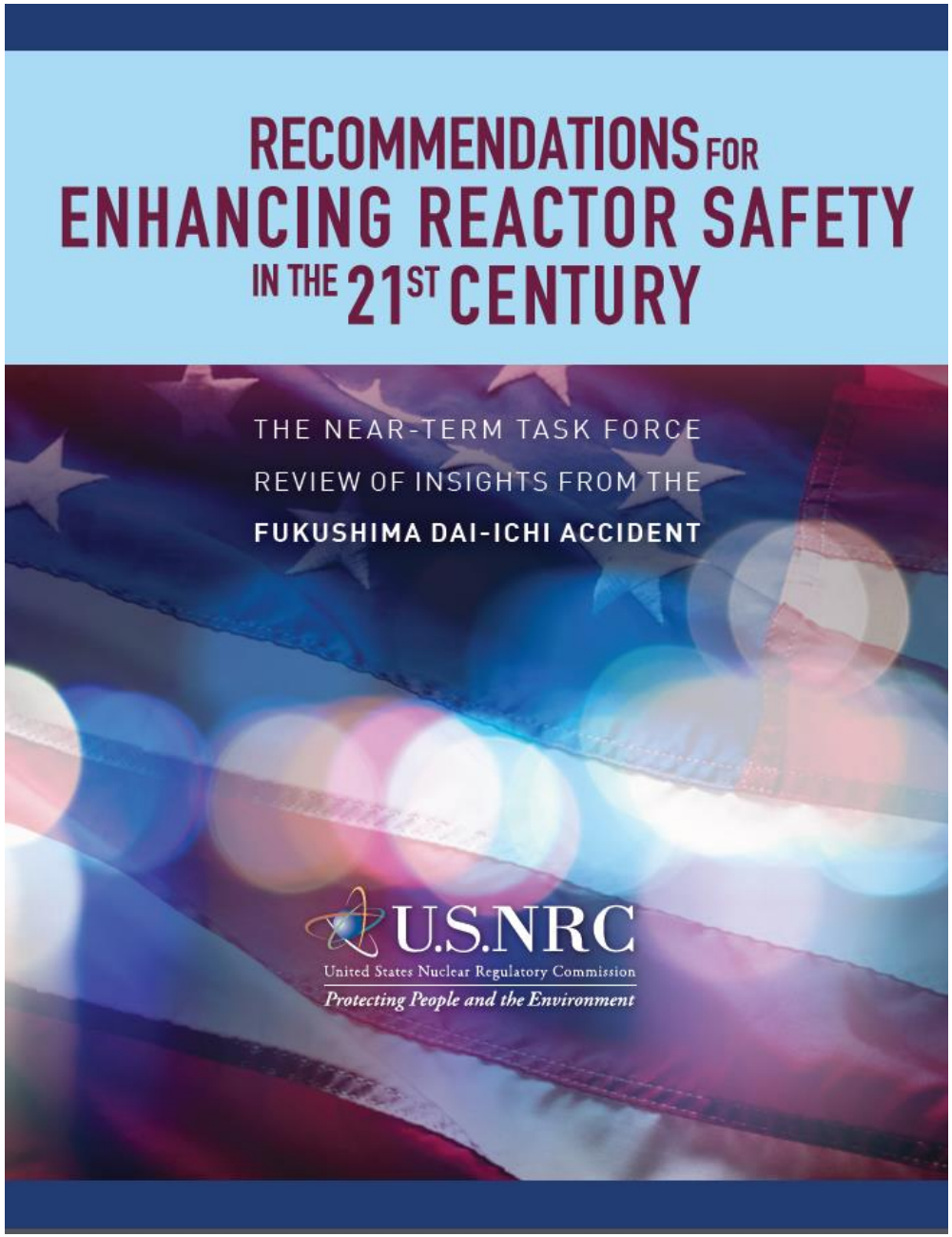
NUREG-2117 *Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies*

- Chapter 6 *Updating: Replacing and Refining Probabilistic Hazard Assessments* is devoted to the updating issue
- Key parts of the updating process are:
  - Identification of new data, models, or methods that have become available
  - Evaluation of the impact of those new findings relative to hazard significance and to the center, body, and range of technically defensible interpretations (CBR of the TDI)
  - If needed, designing the scope and SSHAC Level for the update

Existing Study	Condition of Existing Study	Hazard Assessment Needed	Recommendation	SSHAC Level for New Study
No study, or previous studies conducted at lower SSHAC Levels (2 or 1), or non-SSHAC studies	Not adequate for nuclear/critical facilities	Regional and/or site-specific	Conduct new study	3 or 4
Regional or site-specific	Not viable**	Regional and/or site-specific	Replace existing study	3 or 4
Regional or site-specific	Viable	Site-specific	Refine regional study locally consistent with RG 1.208 and ANSI/ANS-2.27 / 2.29 2008	2, 3, or 4
Site-specific (one or more sites), no regional	Viable	Regional	Use site-specific studies to assist development of regional models	3 or 4
Site-specific (one or more sites), no regional	Not Viable	Regional	Conduct new study	3 or 4

**"Viable" is defined as: (1) based on a consideration of data, models, and methods in the larger technical community, and (2) representative of the center, body, and range of technically defensible interpretations.

NUREG-2117


RECOMMENDATIONS FOR
ENHANCING REACTOR SAFETY
IN THE 21ST CENTURY
THE NEAR-TERM TASK FORCE
REVIEW OF INSIGHTS FROM THE
FUKUSHIMA DAI-ICHI ACCIDENT
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NTTF Recommendations

Recommendation 2

The Task Force recommends that the NRC require licensees to reevaluate and upgrade as necessary the design-basis seismic and flooding protection of SSCs for each operating reactor.

The Task Force recommends that the Commission direct the following actions to ensure adequate protection from natural phenomena, consistent with the current state of knowledge and analytical methods. These should be undertaken to prevent fuel damage and to ensure containment and spent fuel pool integrity:

Being implemented

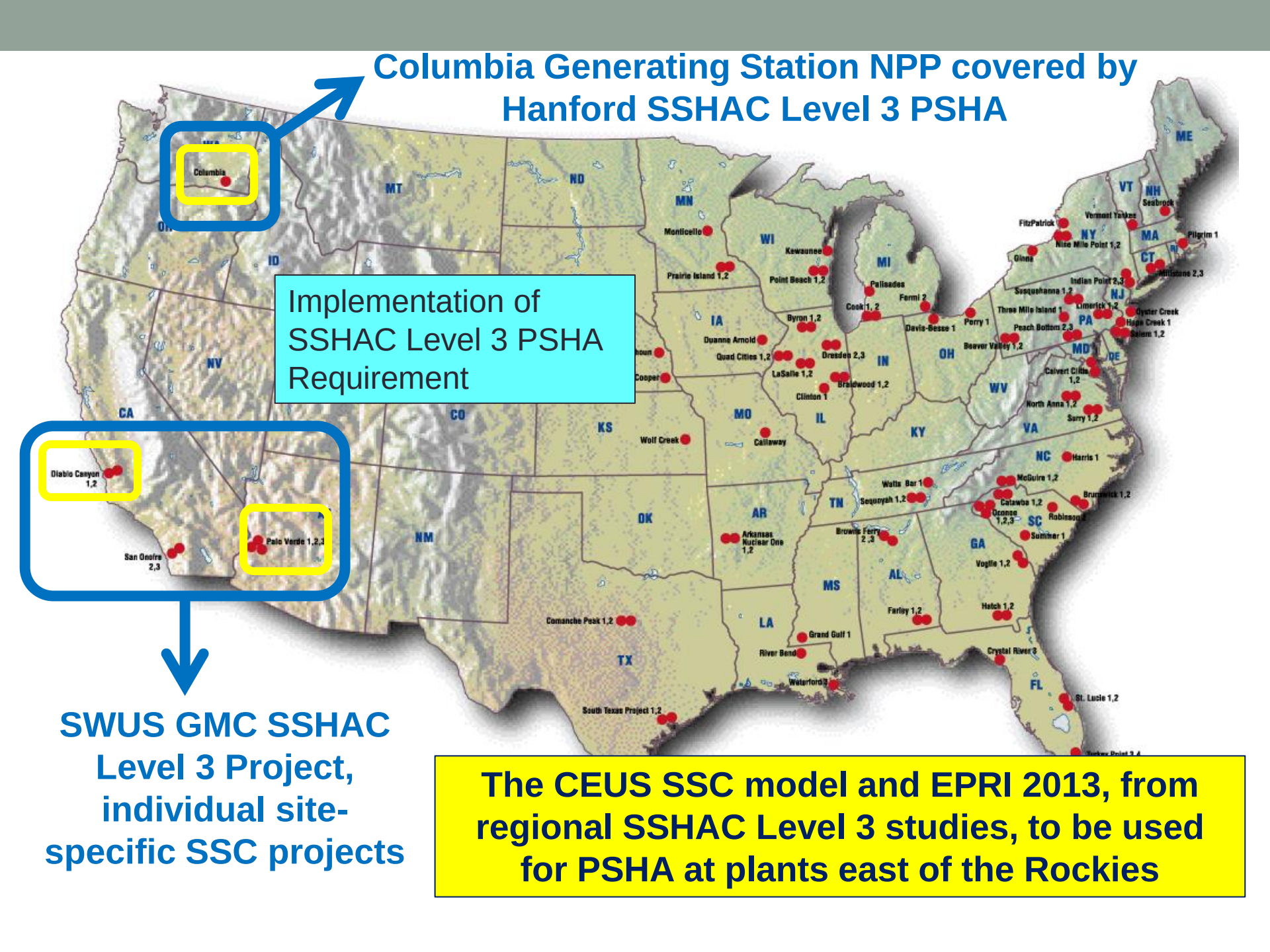
2.1 Order licensees to reevaluate the seismic and flooding hazards at their sites against current NRC requirements and guidance, and if necessary, update the design basis and SSCs important to safety to protect against the updated hazards.

Contemplated

2.2 Initiate rulemaking to require licensees to confirm seismic hazards and flooding hazards every 10 years and address any new and significant information. If necessary, update the design basis for SSCs important to safety to protect against the updated hazards.

Being implemented

2.3 Order licensees to perform seismic and flood protection walkdowns to identify and address plant-specific vulnerabilities and verify the adequacy of monitoring and maintenance for protection features such as watertight barriers and seals in the interim period until longer term actions are completed to update the design basis for external events.


Columbia Generating Station NPP covered by Hanford SSHAC Level 3 PSHA
Implementation of SSHAC Level 3 PSHA Requirement
SWUS GMC SSHAC Level 3 Project, individual site-specific SSC projects
The CEUS SSC model and EPRI 2013, from regional SSHAC Level 3 studies, to be used for PSHA at plants east of the Rockies
Columbia
Diablo Canyon 1,2
Palo Verde 1,2,3
San Onofre 2,3
Monticello
Prairie Island 1,2
Kewaunee
Point Beach 1,2
Palisades
Fermi 2
Cook 1, 2
Davis-Besse 1
Perry 1
Beaver Valley 1,2
Duane Arnold
Quad Cities 1,2
Byron 1,2
Dresden 2,3
LaSalle 1,2
Braidwood 1,2
Clinton 1
Cooper
Wolf Creek
Callaway
Arkansas Nuclear One 1,2
Comanche Peak 1,2
South Texas Project 1,2
Grand Gulf 1
River Bend
Waterford 3
Browns Ferry 2,3
Watts Bar 1
Sequoyah 1,2
Farley 1,2
Vogtle 1,2
Hatch 1,2
Crystal River 3
St. Lucie 1,2
Summer 1
Oconee 1,2,3
Catawba 1,2
McGuire 1,2
Harris 1
Robinson 2
Brunswick 1,2
Surry 1,2
North Anna 1,2
Calvert Cliffs 1,2
Peach Bottom 2,3
Three Mile Island 1
Susquehanna 1,2
Limerick 1,2
Oyster Creek
Hope Creek 1
Salem 1,2
Millstone 2,3
Indian Point 2,3
Nine Mile Point 1,2
FitzPatrick
Ginna
Vermont Yankee
Seabrook
Pilgrim 1

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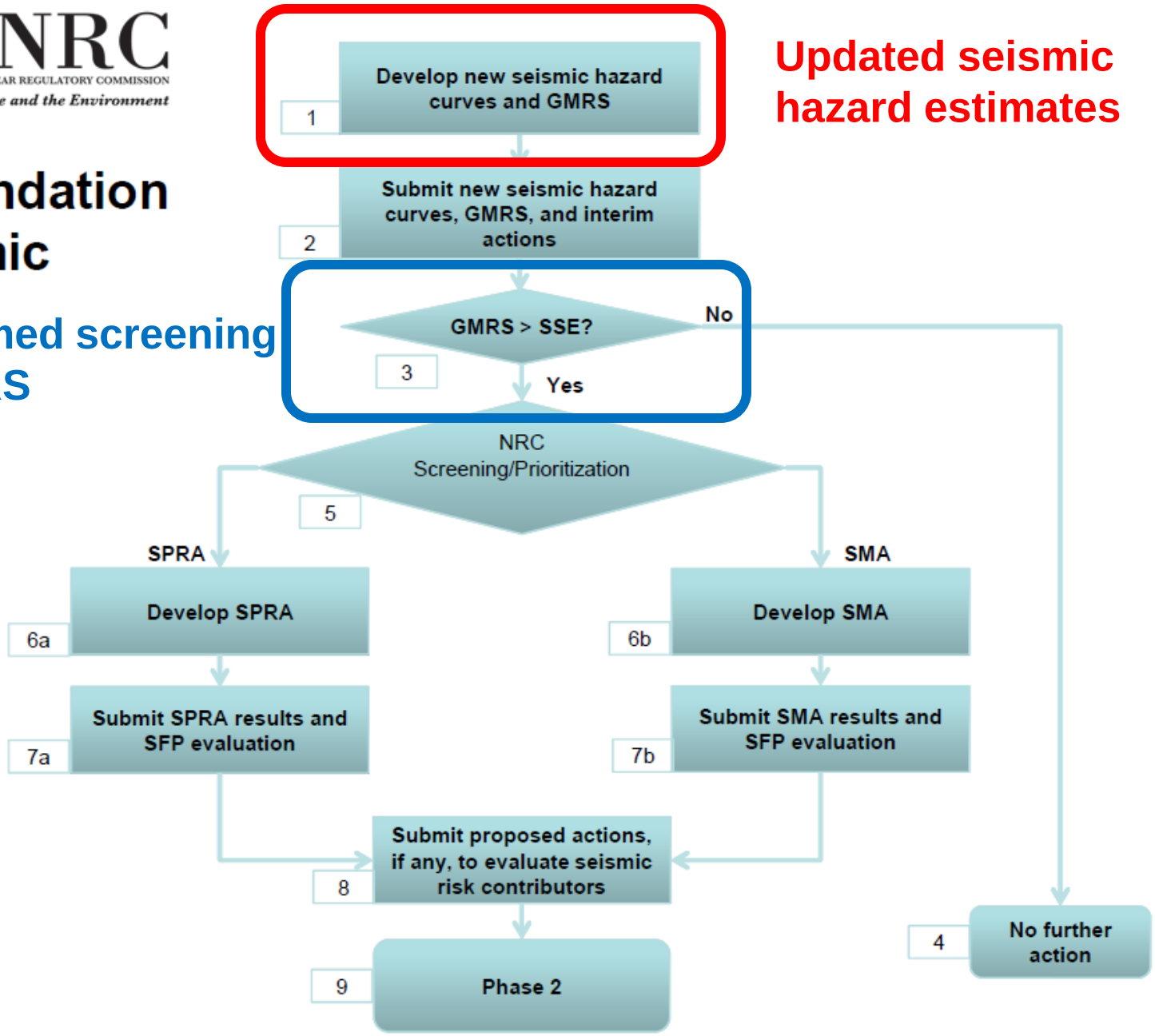
Protecting People and the Environment

Recommendation 2.1: Seismic

Risk-informed screening using GMRS



Updated seismic hazard estimates

Criteria for Evaluating the Need for an Update of an Existing PSHA

- Criterion #1: New data, models, and methods developed since the existing PSHA
- Criterion #2: New inputs to the PSHA model, including the SSC, GMC, and site response models
  - Includes the treatment of aleatory and epistemic uncertainties
  - Termed “viable” in NUREG-2117: captures center, body, and range of technically-defensible interpretations
- Criterion #3: Changes in the technical bases
  - Technical arguments and justifications for the hazard inputs and the associated treatment of uncertainties
- Criterion #4: Significant changes in mean hazard
  - Need to consider the precision or “noise” levels of hazard calculations

Goal of a SSHAC Process

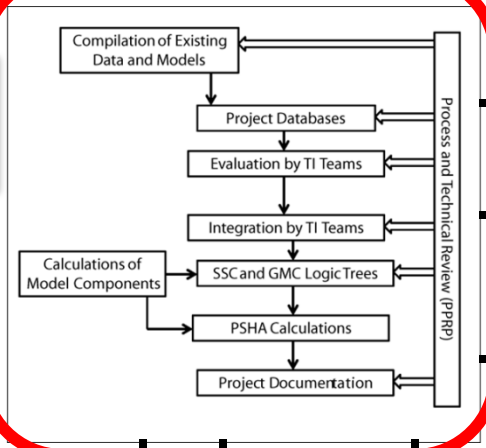
"The fundamental goal of a SSHAC process is to properly carry out and completely document the activities of evaluation and integration, defined as:

- Evaluation: The consideration of the complete set of data, models, and methods proposed by the larger technical community that are relevant to the hazard analysis.
- Integration: Representing the center, body, and range of technically defensible interpretations in light of the evaluation process (i.e., informed by the assessment of existing data, models, and methods)."

NUREG-2117

Hazard-Related Comparisons

INL SSHAC Level 1 PSHA



Actions and Products to Address Proposed Updating Criteria

1

2

3

Full distribution of hazard curves (mean and fractiles)

Compare with DBGM

Compare with existing PSHA

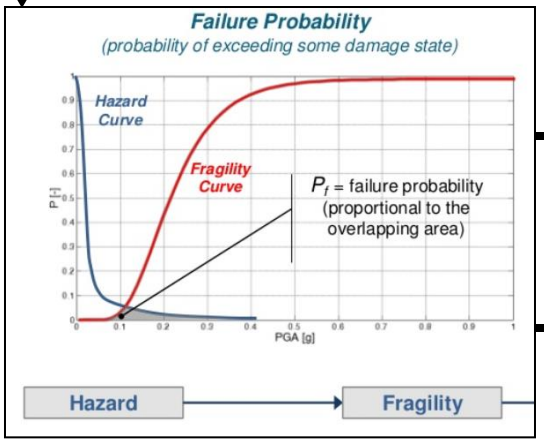
4

5

Proposed Criteria for Evaluating Need for Update

1. New data, models, or methods
2. Changes in inputs to hazard
3. Changes in technical bases
4. Significant changes in hazard
5. Compare SDC-3,4,5 ground motion with design basis ground motion (DBGM)
6. GMRS vs. DBGM comparison
7. Risk vs. objectives and performance goals

Risk-Related Comparisons

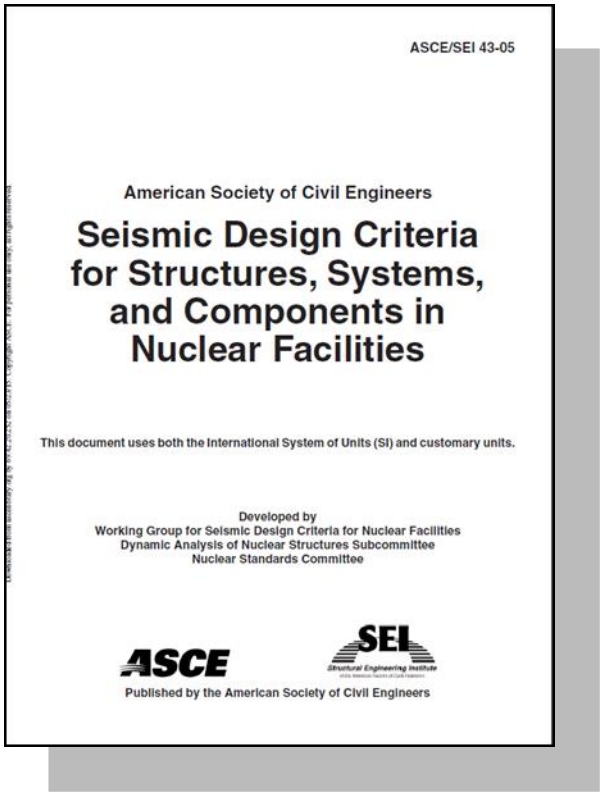


6

7

ASCE/SEI 43-05

- Performance-based approach to ensure facility achieves desired performance
- Tells us where to enter the mean hazard curve to achieve a desired performance objective and, in turn, to mitigate defined dose consequence



Design Parameters and Target Performance Goals in ASCE 43-05

Earthquake Design Parameters			
	SDC		
	3	4	5
Target Performance Goal (P_F)	1×10^{-4}	4×10^{-5}	1×10^{-5}
Probability Ratio (R_P)	4	10	10
Hazard Exceedance Probability (H_D)	4×10^{-4}	4×10^{-4}	1×10^{-4}
Note: $H_D = R_P \times P_F$			

Table 1.1-2, ASCE/SEI 43-05

U.S. NUCLEAR REGULATORY COMMISSION March 2007

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 1.208

(Draft was issued as DG-1146, dated October 2006)

A PERFORMANCE-BASED APPROACH TO DEFINE THE SITE-SPECIFIC EARTHQUAKE GROUND MOTION

Regulatory Guide 1.208

One of the objectives in developing the performance-based GMRS is to achieve approximately consistent performance for SSCs, across a range of seismic environments, annual probabilities, and structural frequencies. The intent is to develop a site-specific GMRS that achieves the P_F that ensures that the performance of the SSCs related to safety and radiological protection is acceptable.

The performance-based approach combines a conservative characterization of ground motion hazard with equipment/structure performance (fragility characteristics) to establish risk-consistent GMRS, rather than only hazard-consistent ground shaking, as occurs using the hazard reference probability approach in Appendix B to Regulatory Guide 1.165 (Ref. 5). The performance target (the mean annual probability of SSCs reaching the limit state of inelastic response) results from the modification of the UHRS at the free-field ground surface by a design factor to obtain the performance based site-specific GMRS. The design factor achieves a relatively consistent annual probability of plant component failure across the range of plant locations and structural frequencies. It does this by accounting for the slope of the seismic hazard curve, which changes with structural frequency and site location. The design factor ensures that the site-specific response spectrum is equal to or greater than the mean 1 E-04 UHRS.

RG 1.208 Performance-Based GMRS

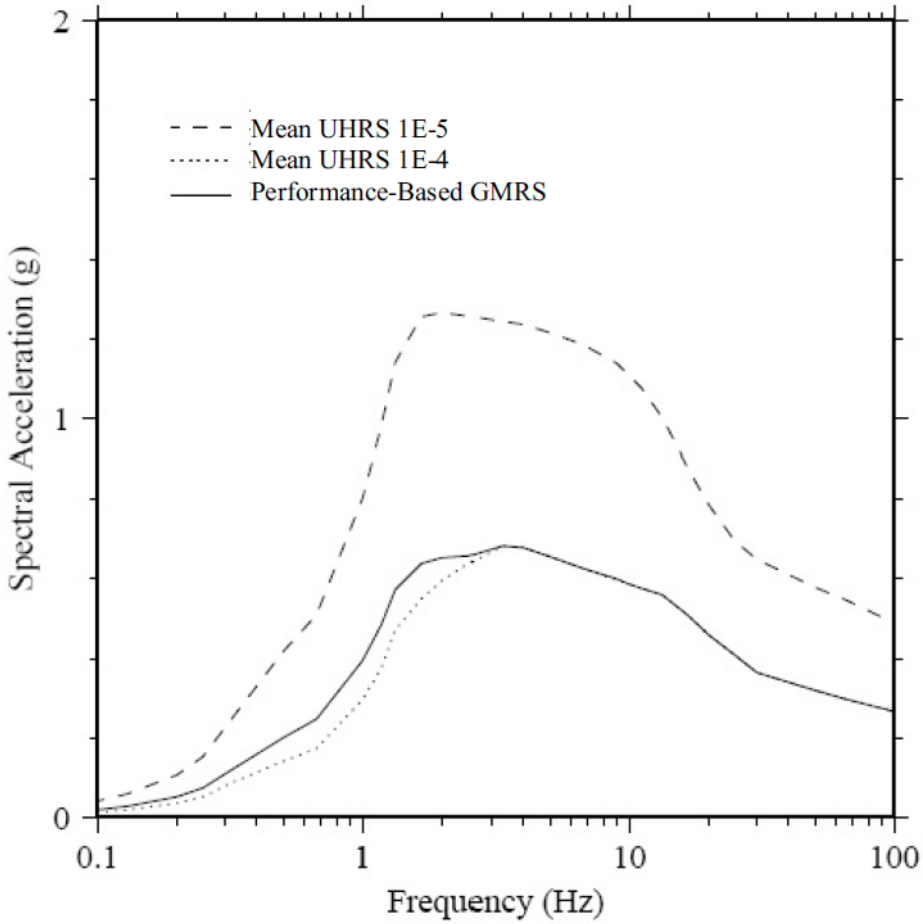
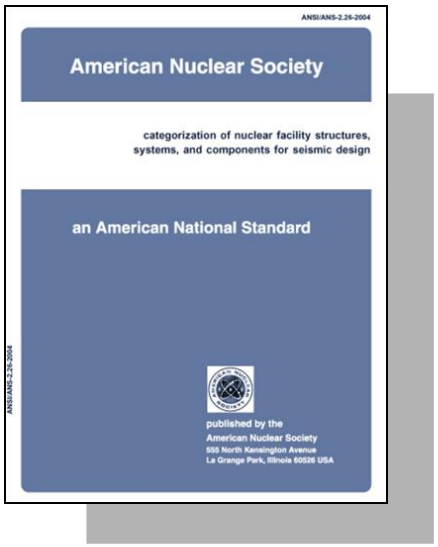


Figure 2. Comparison of the Mean 1 E-04 and 1 E-05 Uniform Hazard Response Spectra and the Performance-Based Ground Motion Response Spectrum (GMRS)

Criteria for Evaluating the Need for an Update of an Existing PSHA (continued)

- Criterion #5: Compare mean hazard at AFE for specific SDC level with design basis ground motions (DBGM)
- Criterion #6: Compare mean hazard at AFE for specific SDC level with GMRS
  - Intended to ensure meeting target performance goals
  - GMRS includes a factor to account for slope of hazard curve
  - RG 1.208 defines GMRS for SDC-5; being developed for ASCE 43
- Criterion #7: Risk insights: Compare mean risk with target performance goals for SDC level; compare GMRS with HCLPF capacity

ANSI/ANS-2.26-2004; Reaffirmed 2010



Seismic Design Category (SDC): A category assigned to an SSC, which is a function of the severity of adverse radiological and toxicological effects of the hazards that may result from the seismic failure of the SSC on workers, the public, and the environment. SSCs may be assigned to Seismic Design Categories that range from 1 to 5.

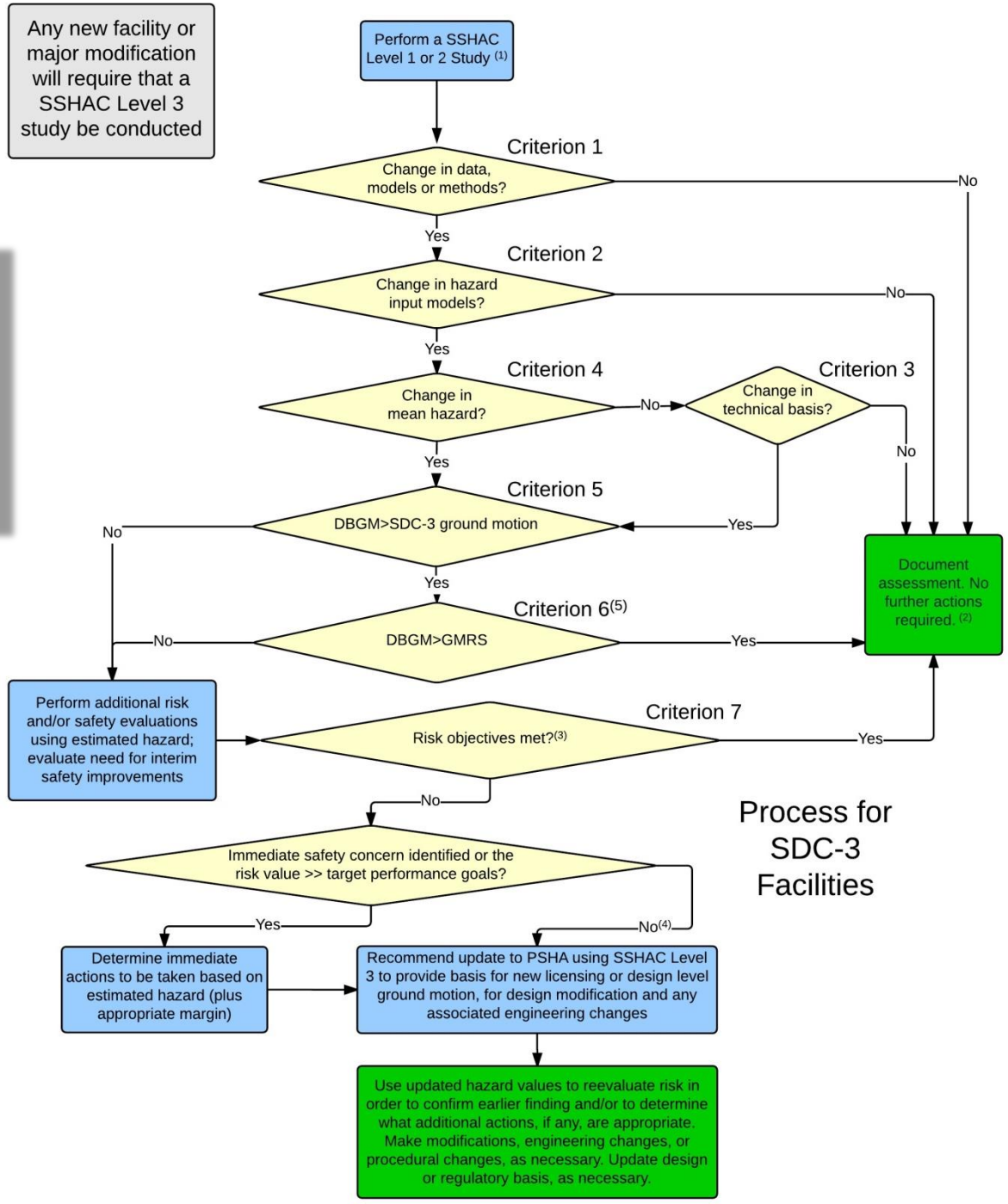
Table 1 – SDCs based on the unmitigated consequences of SSC failure

Category	Unmitigated Consequence of SSC Failure		
	Worker	Public	Environment
SDC-1[a)]	No radiological/ toxicological release consequences but failure of SSCs may place facility workers at risk of physical injury.	No radiological/ toxicological release consequences.	No radiological/ toxicological release consequences.
SDC-2[a)]	Radiological/ toxicological exposures to workers will have no permanent health effects, may place more facility workers at risk of physical injury, or may place emergency facility operations at risk.	Radiological/ toxicological exposures of public areas are small enough to require no public warnings concerning health effects.	No radiological or chemical environmental consequences.
SDC-3	Radiological/ toxicological exposures that may place facility workers' long-term health in question.	Radiological/ toxicological exposures of public areas would not be expected to cause health consequences but may require emergency plans to assure public protection.	No long-term environmental consequences are expected, but environmental monitoring may be required for a period of time.
SDC-4	Radiological/ toxicological exposures that may cause long-term health problems and possible loss of life for a worker in proximity of the source of hazardous material, or place workers in nearby on-site facilities at risk.	Radiological/ toxicological exposures that may cause long-term health problems to an individual at the exclusion area boundary for 2 hours.	Environmental monitoring required and potential temporary exclusion from selected areas for contamination removal.
SDC-5	Radiological/ toxicological exposures that may cause loss of life of workers in the facility.	Radiological/ toxicological exposures that may possibly cause loss of life to an individual at the exclusion area boundary for an exposure of 2 hours.	Environmental monitoring required and potentially permanent exclusion from selected areas of contamination.

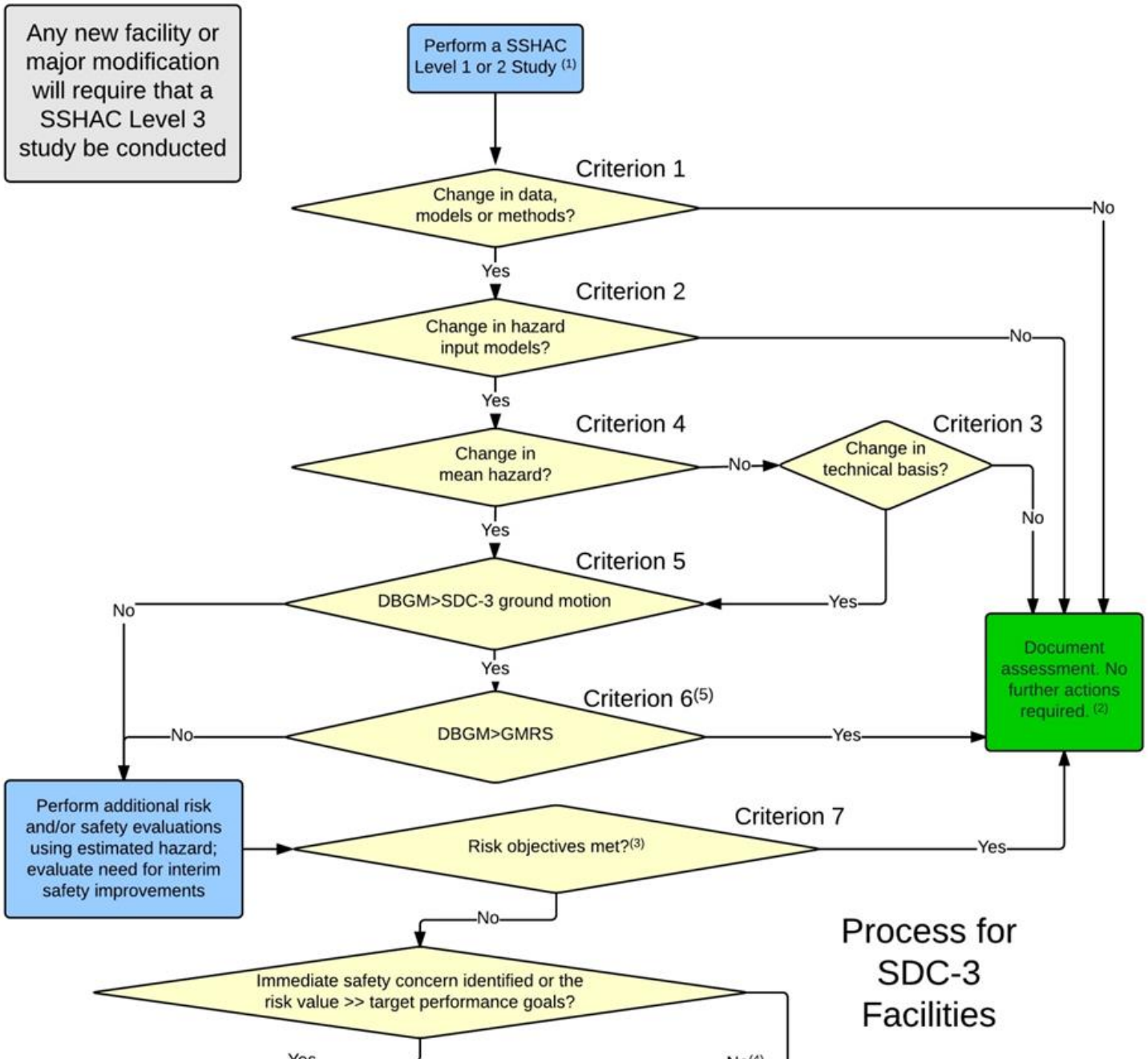
a) "No radiological/toxicological releases" or "no radiological/toxicological consequences" means that material releases that cause health or environment concerns are not expected to occur from failures of SSCs assigned to this category.

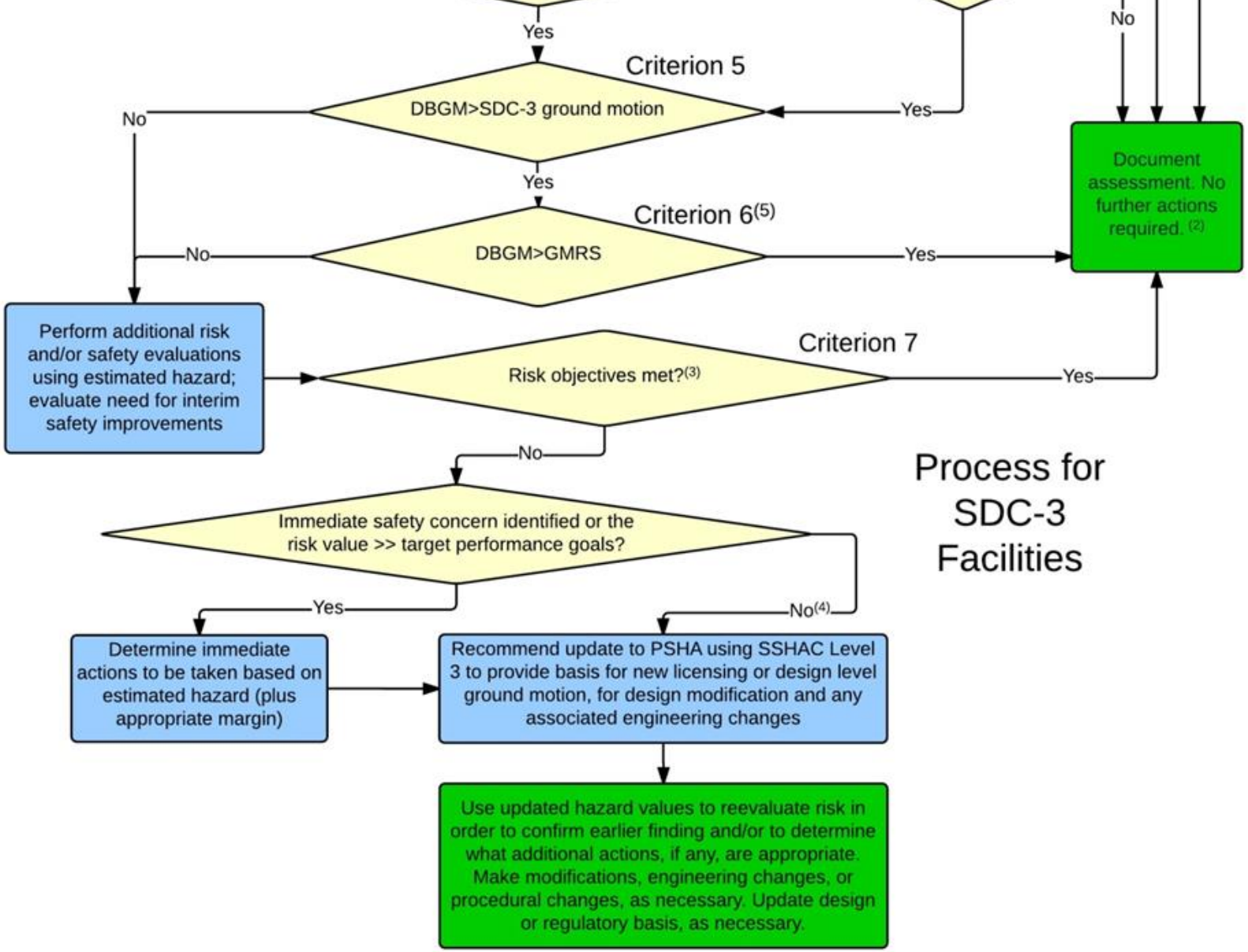
Decision Methodology for Evaluating the Need for an Update of Existing PSHA

SDC-3 Facility



Notes:


Any new facility or major modification will require that a SSHAC Level 3 study be conducted
Perform a SSHAC Level 1 or 2 Study (1)
Criterion 1
Change in data, models or methods?
No
Yes
Criterion 2
Change in hazard input models?
No
Yes
Criterion 4
Change in mean hazard?
No
Criterion 3
Change in technical basis?
No
Yes
Criterion 5
DBGM>SDC-3 ground motion
No
Yes
Document assessment. No further actions required. (2)
Criterion 6(5)
DBGM>GMRS
No
Yes
Perform additional risk and/or safety evaluations using estimated hazard; evaluate need for interim safety improvements
Criterion 7
Risk objectives met?(3)
Yes
No
Immediate safety concern identified or the risk value >> target performance goals?
Process for SDC-3 Facilities

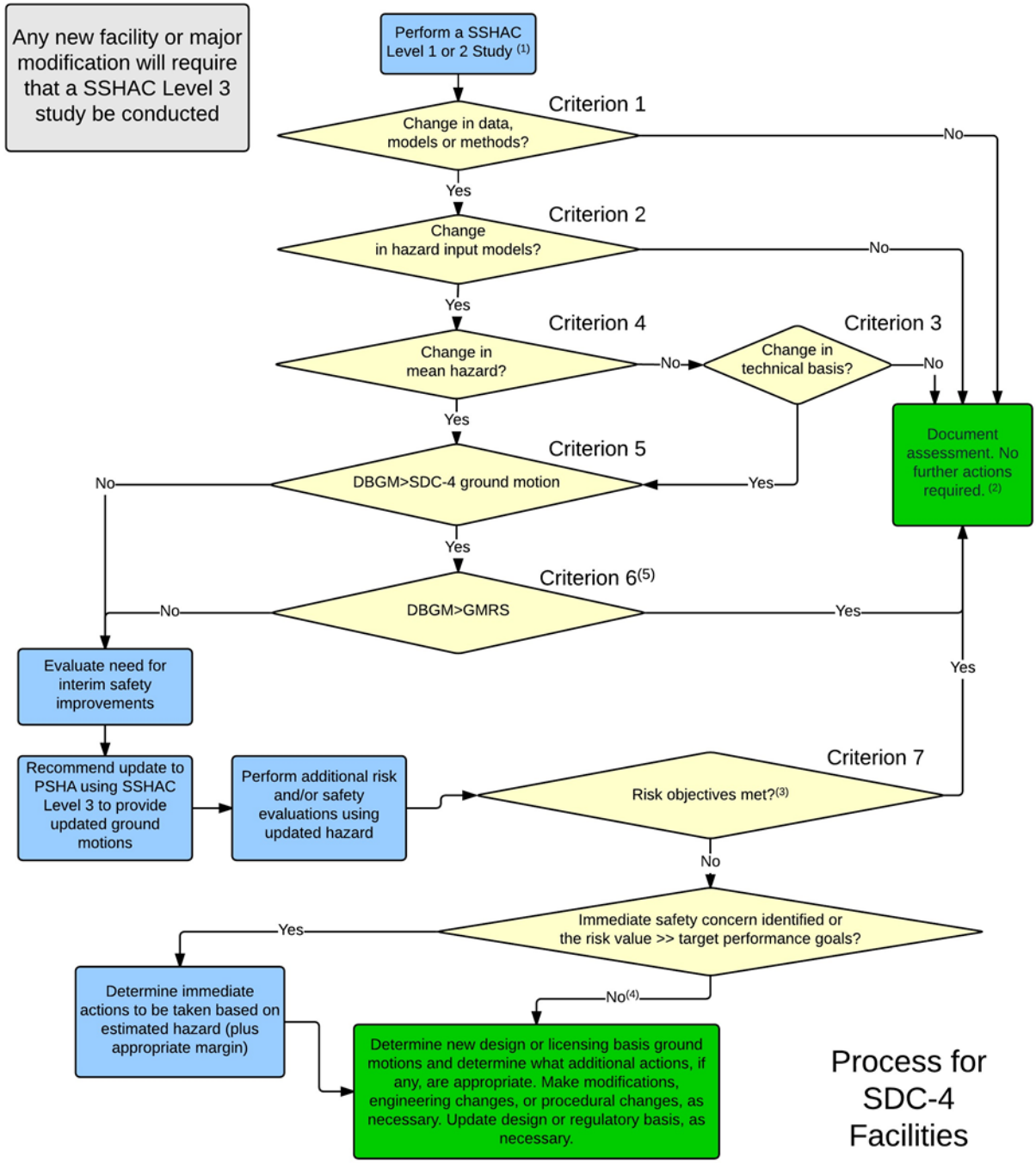


Notes:

1. The SSHAC level 1 or 2 study must include a documented in-process peer review. The resulting estimated hazard should be compared with the existing studies used to develop design or regulatory bases for the facility.
2. The estimated hazard and any risk-informed findings apply to this facility only and cannot be used for other facilities
3. See the report for discussion of the appropriate risk-related information to be considered
4. A "no" determination here indicates that the risk objectives were not shown to be met, but that no immediate safety concern was identified and the risk did not exceed the target by a large amount.
5. Currently design factors needed for developing the GMRS have only been published for SDC-5 Facilities (ASCE 43-05). The next revision

Decision Methodology for Evaluating the Need for an Update of Existing PSHA

SDC-4 Facility

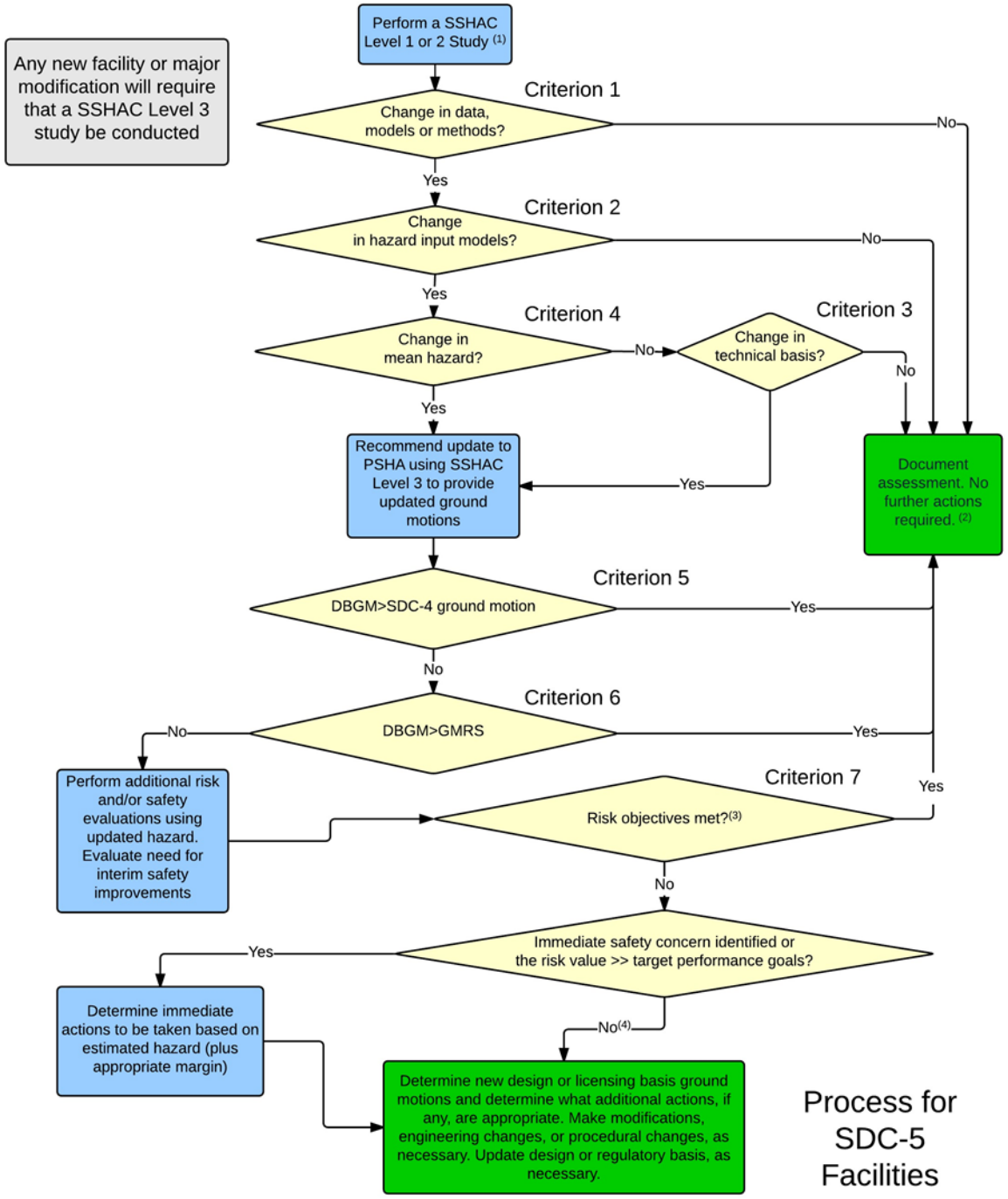


Notes:

1. The SSHAC level 1 or 2 study must include a documented in-process peer review. The resulting estimated hazard should

Decision Methodology for Evaluating the Need for an Update of Existing PSHA

SDC-5 Facility



Process for SDC-5 Facilities

Notes:

Additional Considerations by Panel

- Approach for sites that have recent, defensible SL3 studies and the possibility of site-specific refinements
- Encourage site-wide PSHAs that will benefit multiple facility sites
  - Hanford Site example
  - SL3 PSHA for all sites, with site-specific studies for site response
- Applicability of risk indices (e.g., HCLPF) for SDC-3, and -4 facilities

Conclusions

- DOE Order 420.1C *Facility Safety* requires evaluation of need for NPH update every ten years
- Generic methodology to address should be consistent with existing guidance, plus consider risk information
- Graded approach considers SDC level; higher SDC level having more rigorous actions conducted earlier in decision process
- Seven criteria are identified for evaluating the viability and defensibility of existing PSHA
- All decision methodologies require thorough documentation to support either decision to update or to not update
- Comments welcome on this preliminary methodology